Current and Long Range Great Salt Lake Water Quality Initiatives

Utah Section of the AWRA
Walt Baker, P.E., Director
Utah Division of Water Quality

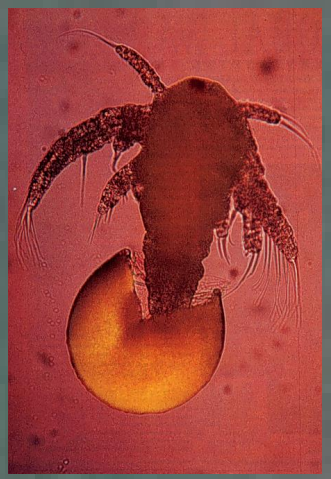
Great Salt Lake Infra-red Satellite View

High Water

Class 5: The Great Salt Lake

- No numeric standards
- Protected for primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary aquatic organisms in their food chain, and mineral extraction

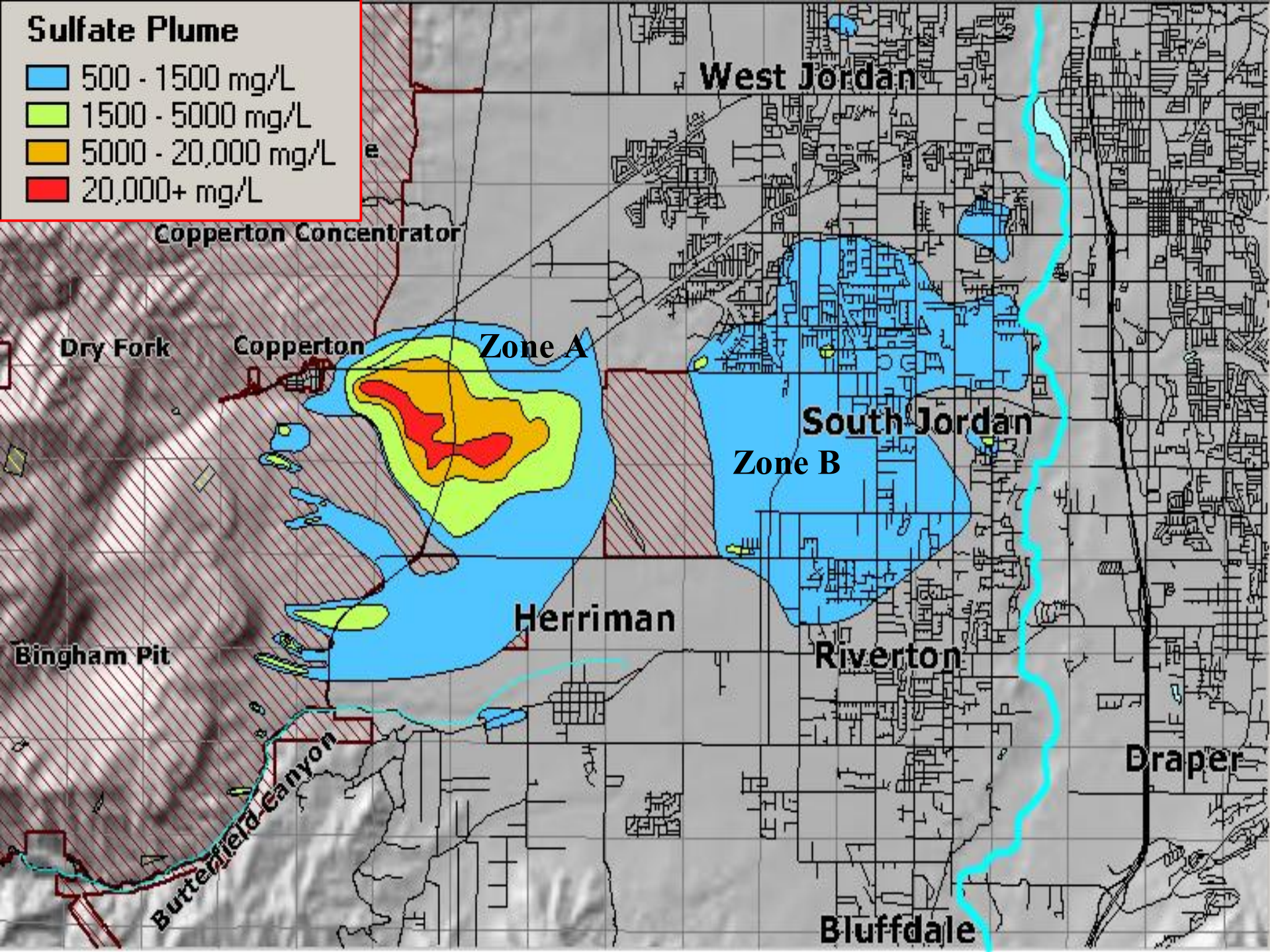
Industry – Brine Shrimp Cysts
Birds – Brine Shrimp & Cysts, and Brine Flies



The Great Salt Lake

- Largest lake west of the Mississippi
- 4th largest terminal lake in the world; over 3,000 mi^2
- 3 to 5 times saltier than the ocean
- Maximum depth is 35 feet; average depth is 13 feet
- Supports between 2 and 5 million shorebirds
- Supports mineral and chemical extraction; brine shrimp industry; duck clubs; and recreation
- Home to 98% of Utah's swans; 70% of the ducks; and 31% of the Canada Geese
- Supports 85% of the state's wetlands
- >80% of the wastewater in the state flows into the GSL

Bingham Copper Mine


Sulfate Plume
500 - 1500 mg/L
1500 - 5000 mg/L
5000 - 20,000 mg/L
20,000+ mg/L
West Jordan
Copperton Concentrator
Dry Fork
Copperton
Zone A
South Jordan
Zone B
Herriman
Riverton
Bingham Pit
Butterfield Canyon
Draper
Bluffdale

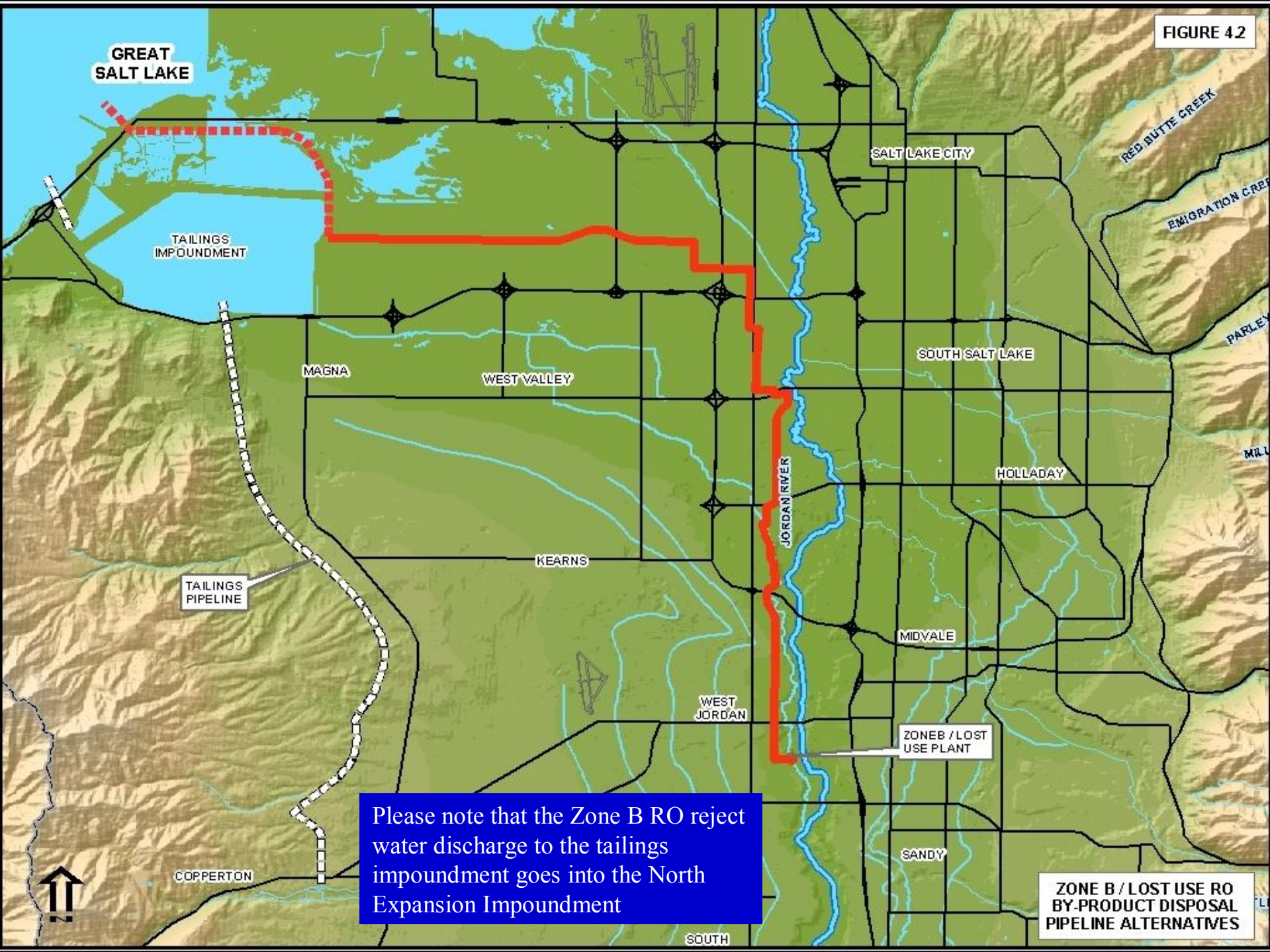


FIGURE 4.2
GREAT SALT LAKE
TAILINGS IMPOUNDMENT
SALT LAKE CITY
RED BUTTE CREEK
EMIGRATION CREEK
PARLEY
SOUTH SALT LAKE
MAGNA
WEST VALLEY
JORDAN RIVER
HOLLADAY
KEARNS
TAILINGS PIPELINE
MIDVALE
WEST JORDAN
ZONEB / LOST USE PLANT
SANDY
COPPERTON
SOUTH
Please note that the Zone B RO reject water discharge to the tailings impoundment goes into the North Expansion Impoundment
ZONE B / LOST USE RO BY-PRODUCT DISPOSAL PIPELINE ALTERNATIVES

The Original Plan for Zone B Reject Water

- 11 disposal alternatives were evaluated
- Discharge of reject water to the Jordan River was preferred by the JSWCD
- Jordan River is classified as 2B (secondary contact recreation), 3B (warm water fishery), 3D (water fowl) and 4 (agriculture)
- Se standard: 4.6 ug/l
- After mixing, Se levels in the river were projected to be 4.22 ug/l at 7Q10 and 2.7 ug/l at Q_{avg}

Disposal Options

- Overall concern raised during the NRD public comment was impact to the GSL or JR posed by the discharge of the reject water containing selenium and salts.
- Kennecott has agreed to accept the RO reject water into KUCC's tailings ponds from the treatment of deep ground water in Zone B.
- Current UPDES permit recognizes the receipt of this reject water stream. Permit limit for Se is 54 ug/l.

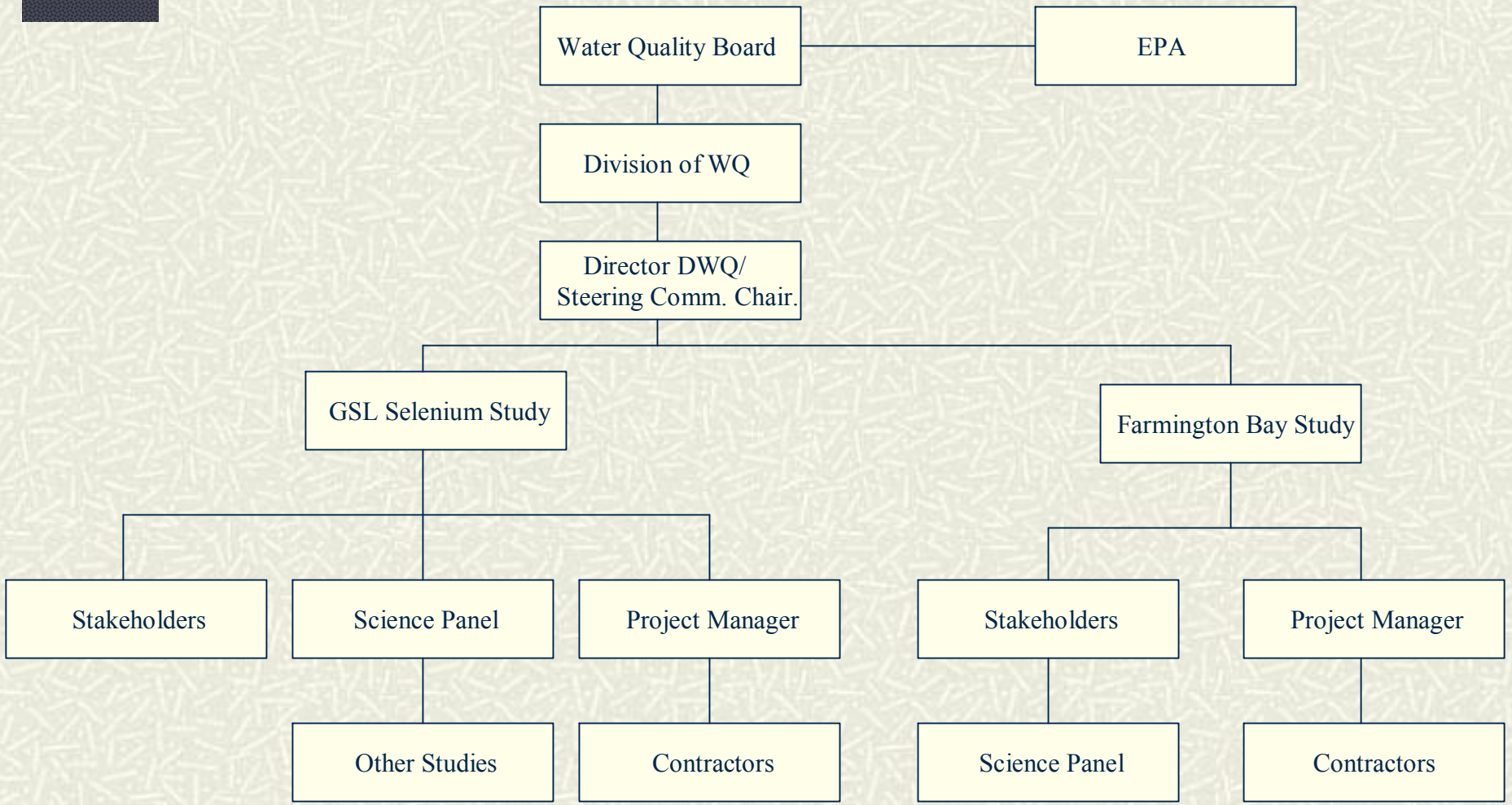
What is a part per billion (ppb)?

- 1 inch in 16,000 miles
- 1 second in 32 years
- 1 cent in $10,000,000
- 1 pinch of salt in 10 tons of potato chips
- 1 bad apple in 2 million barrels

Steering Committee Purpose

- Create a partnership among stakeholders
- Conduct a transparent public process
- Establish a Science Panel
- Sponsor and guide scientific research
- Help secure funding
- Adhere to state & federal laws & regulations
- Make a recommendation to the Water Quality Board on a Se standard for the GSL

Organizational Chart



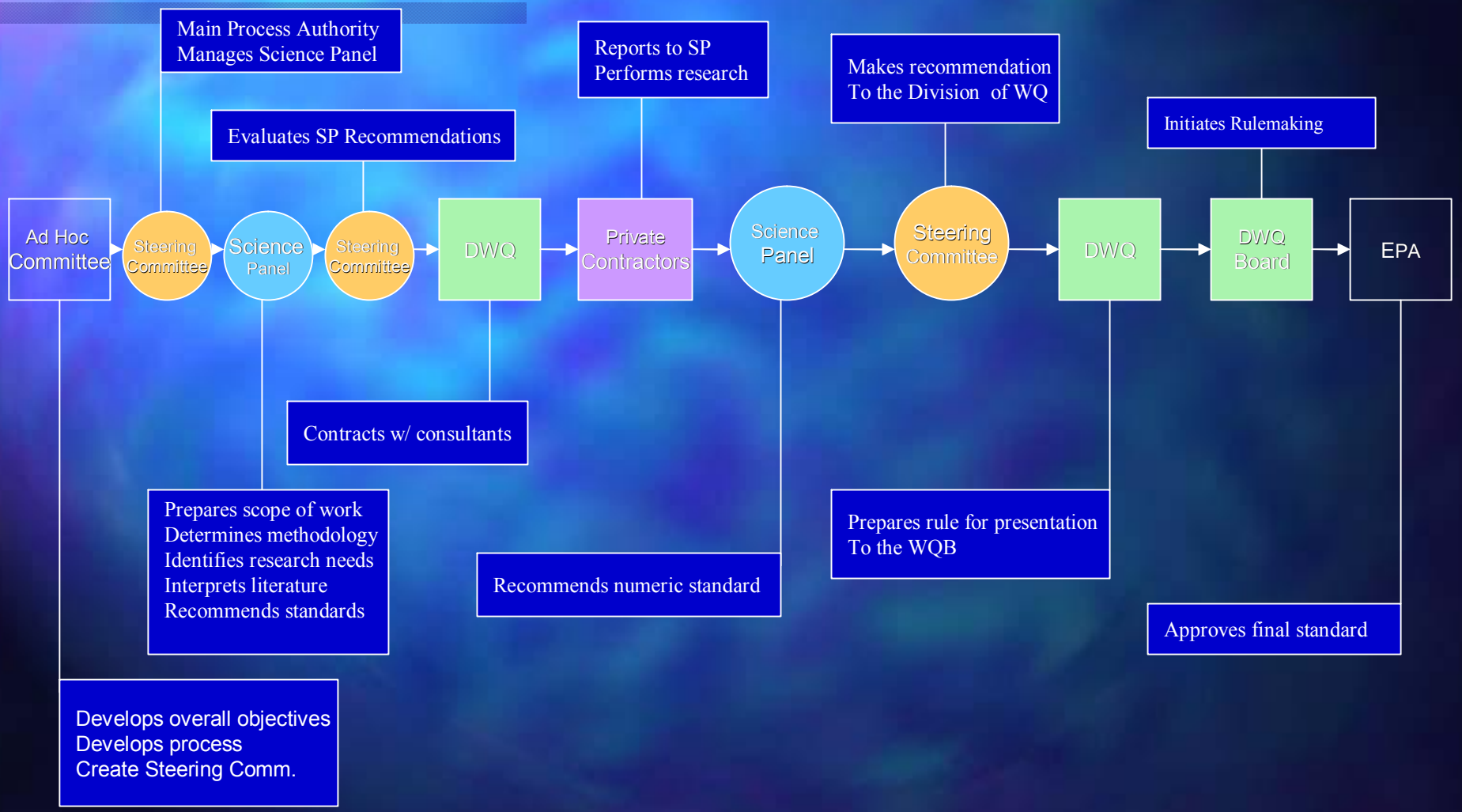
Steering Committee Make-up

1. Forestry & State Lands
2. Wildlife Resources
3. EPA Region VIII
4. US Fish & Wildlife
5. Brine Shrimp Industry
6. Mineral Extractors
7. US Geological Survey
8. Kennecott Utah Copper
9. Jordan Valley WCD
10. POTWs
11. GSL Alliance
12. GSL Alliance
13. Duck Clubs
14. Wasatch Front RC
15. DEQ
16. DWQ

GSL Science Panel

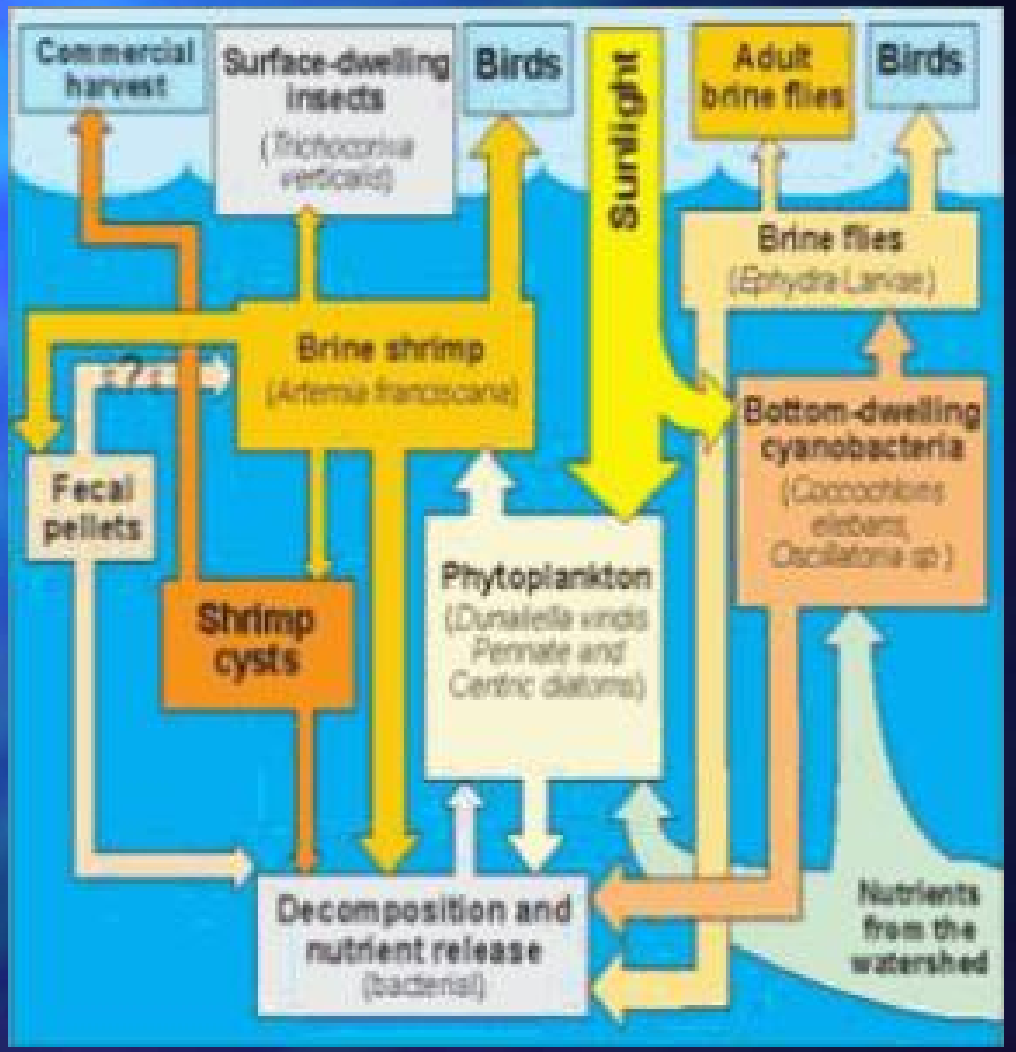
- Bill Adams, Ph.D.
  Rio Tinto
- Anne Fairbrother, Ph.D
  EPA
- Don Hayes, Ph.D
  University of Utah
- Theron Miller, Ph.D
  DWQ
- Bill Moellmer, Ph.D.
  DWQ
- Brad Marden, M.S.,
  Fisheries Consultant
- Terresa Presser, Ph.D.
  US Geological Survey
- Joseph Skorupa, Ph.D.
  US Fish & Wildlife
- Bill Wuerthele, M.S.
  EPA

Standard Setting Process



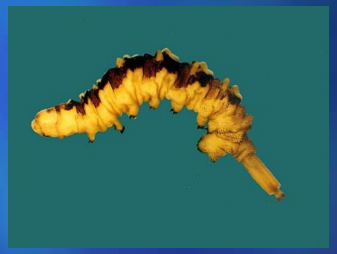
Understanding the Life Cycle

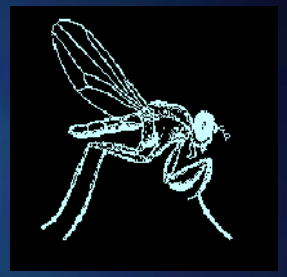
- Determine
  - Movement of Selenium into the Sediments
  - From Sediments into algae, brine flies, and brine shrimp
  - Effect on birds of eating brine flies & shrimp



Biomagnification up the Food Chain

Selenium in the Water





Brine Fly

How much does the Se bio-magnify between the water and the bugs?

Brine Shrimp

Biomagnification up the Food Chain

Brine Flies & Brine Shrimp →

Eared Grebe

California Gull

Black-Necked Stilt

How much does the Se bio-magnify between the bugs and the birds?

Biomagnification up the Food Chain

Birds → Chicks

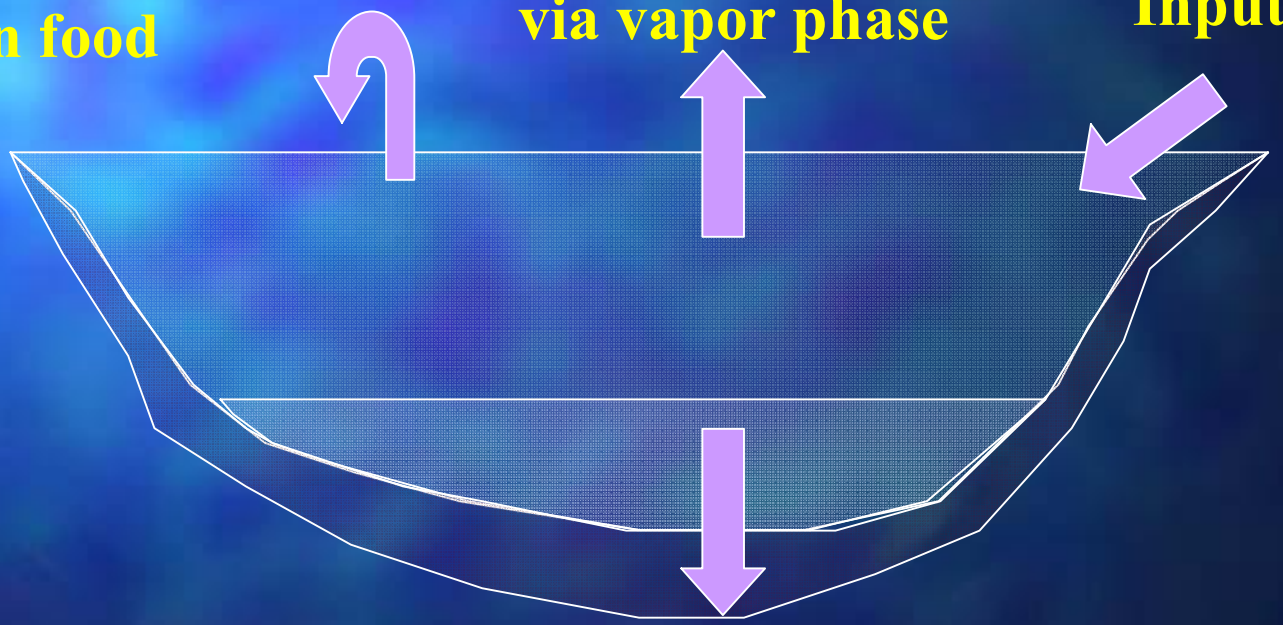
How much does the Se bio-magnify between birds and the chicks?

Meetings

- First Steering Committee meeting was held August 18, 2004; 16 meetings and a conference call have been held since
- First Science Panel meeting was held November 8, 2005; 7 meetings and 4 conference calls have been held since (with untold e-mails)

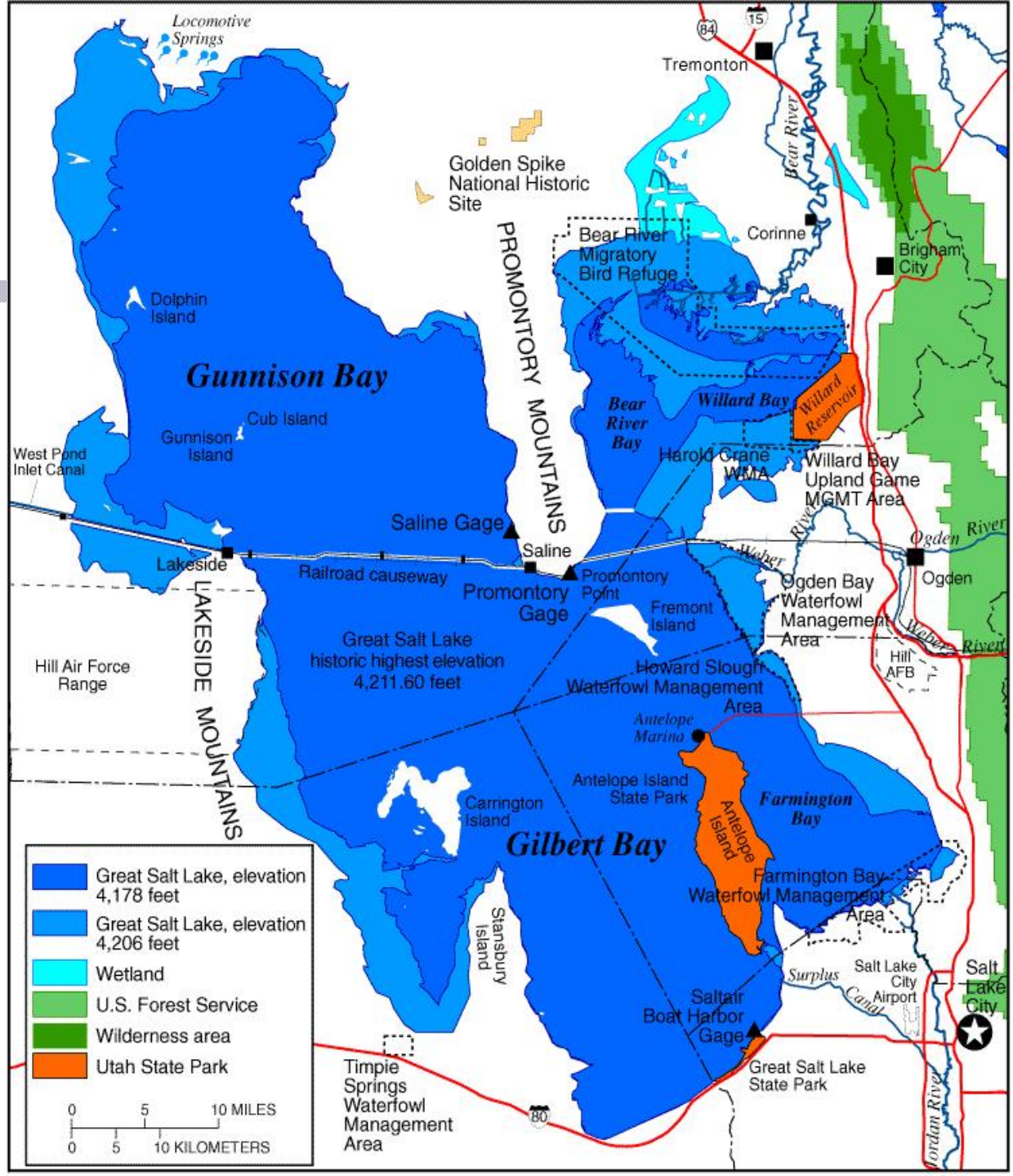
Selenium Study: 4 Components

Output, bioaccumulation, and toxicological endpoints in food chain



Timeline

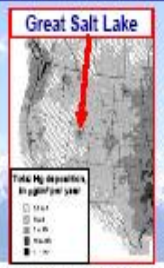
- Nov. 30 – Science Panel makes its recommendation
- Dec. 11 – Stake holder meeting in held on the Science Panel's recommendation
- Dec. 18 – Steering Committee votes on the standard
- Jan. 18 – Recommendation is made to the WQB
- Jan. 25 – Public notice period commences
- March 10 – Public hearing held
- April 18 – WQB adopts a standard
- May 1 – the standard becomes effective


Locomotive Springs
Tremonton
84
15
Bear River
Golden Spike National Historic Site
PROMONTORY MOUNTAINS
Bear River Migratory Bird Refuge
Corinne
Brigham City
Dolphin Island
Gunnison Bay
Bear River Bay
Willard Bay
Willard Reservoir
Cub Island
Gunnison Island
West Pond Inlet Canal
Harold Crane WMA
Willard Bay Upland Game MGMT Area
Saline Gage
Saline
Lakeside
Railroad causeway
Promontory Point
Promontory Gage
Fremont Island
Ogden River
Weber River
Ogden
Ogden Bay Waterfowl Management Area
Great Salt Lake historic highest elevation 4,211.60 feet
Hill Air Force Range
LAKESIDE MOUNTAINS
Howard Slough Waterfowl Management Area
Hill AFB
Antelope Marina
Antelope Island State Park
Carrington Island
Gilbert Bay
Antelope Island
Farmington Bay
Farmington Bay Waterfowl Management Area
Stansbury Island
Surplus Canal
Salt Lake City Airport
Saltair Boat Harbor Gage
Salt Lake City
Great Salt Lake State Park
Timpie Springs Waterfowl Management Area
80
Jordan River
Great Salt Lake, elevation 4,178 feet
Great Salt Lake, elevation 4,206 feet
Wetland
U.S. Forest Service
Wilderness area
Utah State Park
0 5 10 MILES
0 5 10 KILOMETERS

Mercury in water and biota from Great Salt Lake, Utah: Reconnaissance-phase results

David Naftz, USGS, Salt Lake City, UT; Bruce Waddell, USFWS, Salt Lake City, UT; and David Krabbenhoft, USGS, Madison, WI

Little is known about Hg cycling in Great Salt Lake



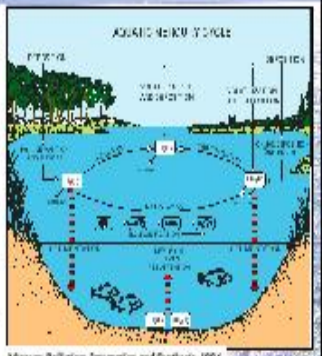
Mercury sources adjacent to GSL

Great Salt Lake (GSL) is the fourth largest terminal lake in the world and may be the most important inland shorebird site in North America (Aldrich and Paul, 2002). In addition to supporting migratory dependent waterbirds, the brine shrimp (Artemia franciscana) population residing in GSL supports a shrimp industry with annual revenues typically exceeding 100 million dollars. Atmospheric deposition is presently the major mercury (Hg) source to most aquatic ecosystems (Krabbenhoft and Rickert, 1995). Based on statistics published in 1997, numerous local point sources for atmospheric Hg deposition to GSL exist (U.S. Environmental Protection Agency, 1997). Based on data compiled from the 1990s, annual Hg deposition adjacent to GSL is elevated, ranging from 3 to 30 µg/m².

U.S. Environmental Protection Agency, 1997

Mercury methylation in GSL

The lipophilic nature of methylmercury (CH_3Hg) and its ability to pass the blood/brain barrier makes it much more toxic to organisms than inorganic forms of Hg. The chemical and physical conditions present in GSL may be ideal for high rates of Hg methylation. Previous work has shown that marine sediments rich in organic matter and dissolved sulfide have rapid CH_3Hg production rates in conjunction with rapid rates of sulfate reduction (King and others, 2000). Sulfate reduction is the principal process leading to the production of CH_3Hg. Rates measured in water from GSL were higher than 6,000 nmole/cm³/day, one of the highest rates reported in a natural environment (Ingvorsen and Brandt, 2002).



Mercury Pollution: Integration and Synthesis, 1994

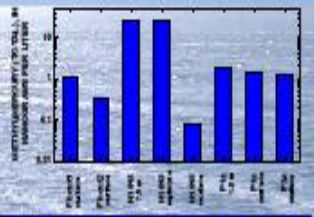
Elevated levels of methyl Hg found in water

Deep brine layer contains methylmercury

Percentage of total Hg concentration as methyl Hg in water samples collected from Great Salt Lake, August 2003.

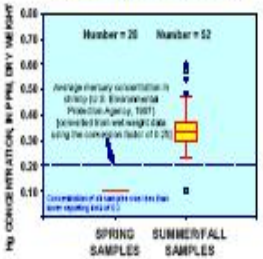
Sample site	Methylmercury as percent of total mercury
FBOUT1 (0 m depth)	8.0
FBOUT2 (0 m depth)	3.7
N1018 (7.5 m depth)	55
N1018 (7.5 m depth) (replicate)	51
N1018 (0 m depth)	1.2
P1A (1.5 m depth)	12
P1A (0 m depth)	9.2
P2A (0 m depth)	9.3

All of the water samples from GSL exceed the total Hg standard for protection of aquatic life in marine systems (British Columbia Ministry of Environment, Lands and Parks, 2001). This standard is based on the ratio of CH_3Hg to total Hg concentrations. In water samples with CH_3Hg making up 5 percent of the total Hg concentration, the standard is 2 ng/L (total Hg). The aquatic life standard increases as the proportion of CH_3Hg relative to total Hg decreases. The percentage of CH_3Hg contributing to total Hg in water samples collected from GSL ranges from 1.2 to 55 percent.

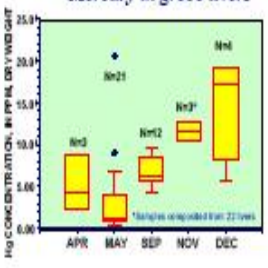


Hg content in biota indicates bioaccumulation

Mercury in brine shrimp



Mercury in grebe livers

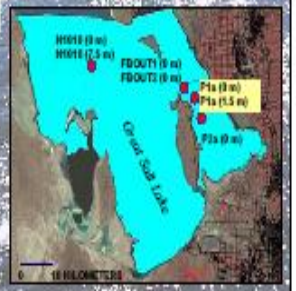


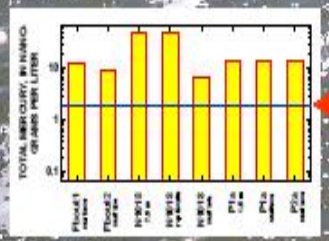
The migration and molting habits of eared grebes make them an ideal population for the reconnaissance evaluation of Hg bioaccumulation. A large population of eared grebes (1.5 million in 1997) from throughout North America utilize GSL during the molt migration beginning in August and continuing through December and January (Aldrich and Paul, 2002). The seasonal changes in Hg concentration in eared grebe livers indicate bioaccumulation during the fall molting period when the grebes feed exclusively on brine shrimp. Brine shrimp samples collected during the summer and fall have a higher Hg concentration (median concentration = 0.34 ppm), with 51 out of 52 samples exceeding the average Hg concentration in shrimp of 0.18 ppm (U.S. Environmental Protection Agency, 1997). Total Hg and CH_3Hg levels in GSL water and biota appear elevated when compared to standards intended to protect aquatic life; however, the amount of data presently available is limited and further study is warranted.

Elevated concentrations of total Hg found in water

Aquatic life standard exceeded

During August 2003, unfiltered water samples were collected from the south arm of GSL. Samples were analyzed for total Hg and CH_3Hg concentrations by the USGS mercury research laboratory in Madison, Wisconsin. Initial results indicate high levels of total Hg (exceeding 45 nanograms per liter (ng/L) and CH_3Hg (exceeding 25 ng/L) in anoxic regions of the lake where high rates of bacterial-mediated sulfate reduction have been documented. The concentration of CH_3Hg measured in GSL is among the highest ever measured by the USGS mercury laboratory.





Total mercury concentration standard in water from marine systems for protection of aquatic life when methyl mercury is 5 percent of the total mercury concentration (British Columbia Ministry of Environment, Lands and Parks, 2001)

References

Aldrich, T.W., and Paul, D.S., 2002, Avian ecology of Great Salt Lake, in Gwynn, J.W., ed., Great Salt Lake: An overview of change, Utah Department of Natural Resources Special Publication, p. 343-374.

British Columbia Ministry of Environment, Lands and Parks, 2001, Ambient water quality guidelines for mercury: Overview report—Final update: accessed September 10, 2004, at URL http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/mercury/HgOverall.html

Ingvorsen, K., and Brandt, K.K., 2002, Anaerobic microbiology and sulfur cycling in hypersaline sediments with special reference to Great Salt Lake, in Gwynn, J.W., ed., Great Salt Lake: An overview of change, Utah Department of Natural Resources Special Publication, p. 287-308.

King, J.K., Kostka, J.E., Fletcher, M.B., and Saunders, F.M., 2000, Sulfate-reducing bacteria methylate mercury at variable rates in pure culture and marine sediments: Applied and Environmental Microbiology, vol. 66, no. 6, p. 2430-2437.

Krabbenhoft, D.P., and Rickert, D.A., 1995, Mercury contamination of aquatic ecosystems: U.S. Geological Survey Fact Sheet 216-95, 4 p.

Mason, R.P., and Sullivan, K.A., 2002, Mercury and methylmercury concentrations in water and biota from Great Salt Lake: accessed September 22, 2004, at URL http://www.chesapeakebay.net/pubs/subcommittee/sav/GSL_Hg_Data.pdf

U.S. Environmental Protection Agency, 1997, Mercury study report to Congress: USEPA Report 452/R-97-003.

In 2003, USGS measured some of the highest levels of Hg found in U.S. surface waters

Activists say Utah should test its waters for mercury

Government , industry need to do more to resolve mercury issue

Toxic mercury lurking in Great Salt Lake

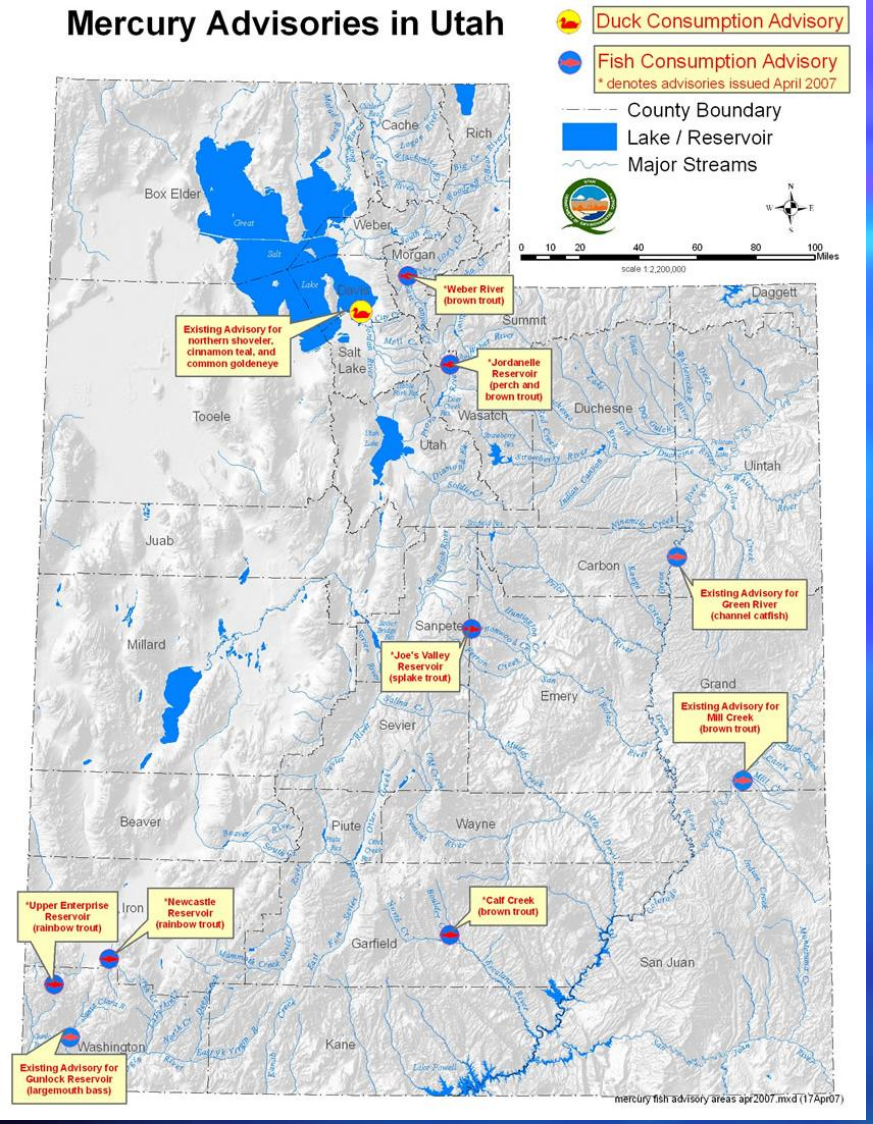
Mercury too high in Utah test fish

Salt Lake Tribune

It's raining mercury

Mercury a worry for duck hunters

A poison wind: Toxic mercury blows into Utah from Nevada

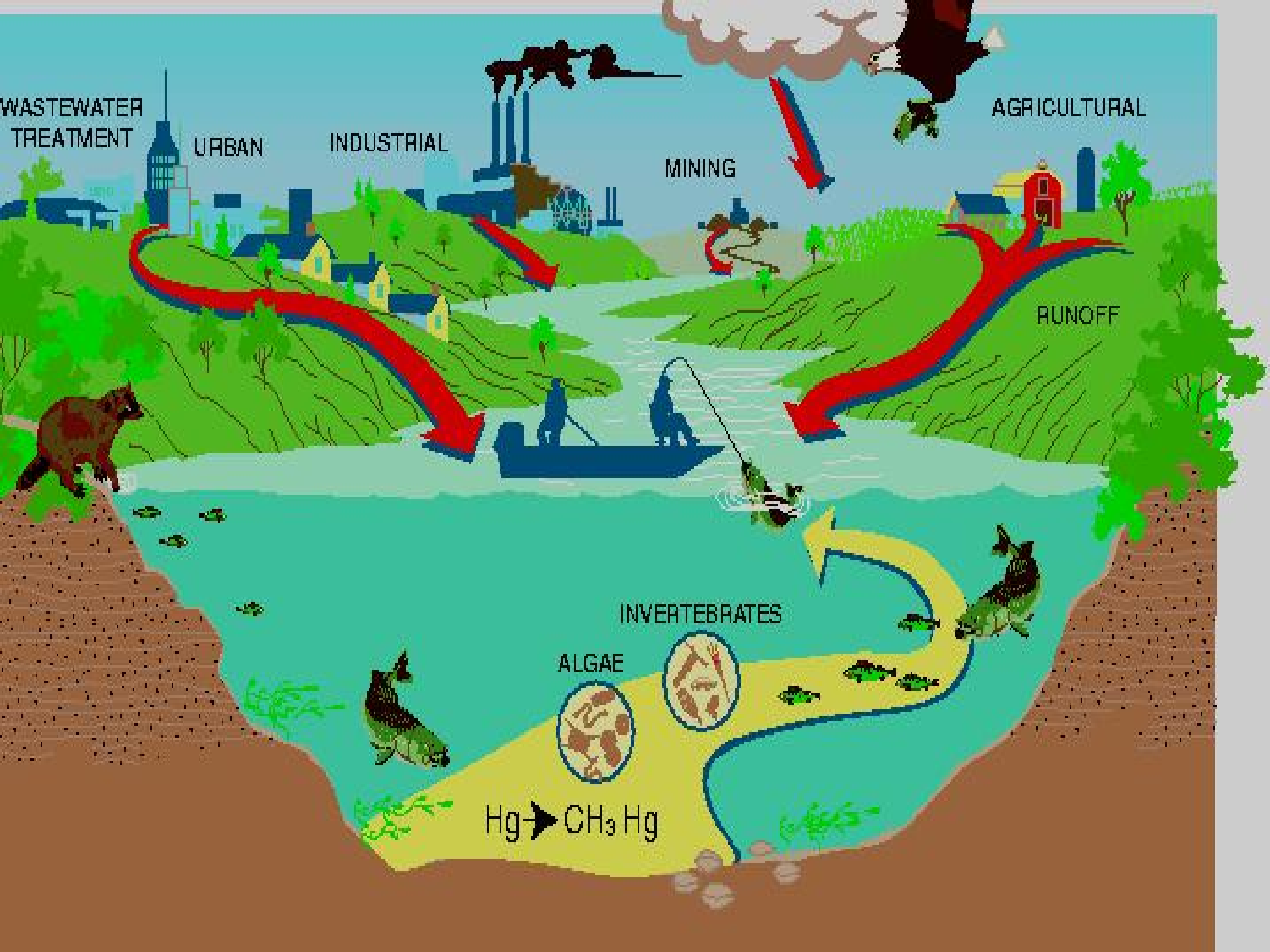


Funding Secured: $66,500

- Sediment samples
- Water column
- Avian tissue

Funding NOT Secured: $147,500

- 1 FTE
- 500 samples/year
- Evaluate hotspots


WASTEWATER TREATMENT
URBAN
INDUSTRIAL
MINING
AGRICULTURAL
RUNOFF
INVERTEBRATES
ALGAE
Hg → CH3 Hg

Mercury Work Group

- Department of Health
- Wildlife Resources
- Division of Air Quality
- Division of Water Quality
- Dept. of Agriculture
- EPA
- Duck Club
- Tribal Interests
- University of Utah
- Great Salt Lake Keeper
- Anglers Group
- Utah Mining Association
- Pacificorp
- US Geological Survey
- US Fish & Wildlife
- Environmental Community
- Local Health Department
- Environmental Response & Remediation
- Utah Medical Assoc.

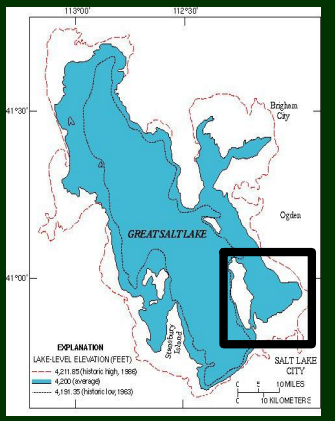
Purpose:

- To provide Utahans with current, accurate and understandable information
- To develop an ongoing monitoring program
- To share information
- To coordinate and collaborate efforts
- To provide mercury advisory information

Where Do We Go From Here?

- Finalize Hg source protocol.
- Execute MOU with Nevada, Idaho, Region 8, Region 9 and Region 10 to pool resources.
- Continue to pursue funding.
- Continue GSL monitoring.
- Solicit regional and national interest.

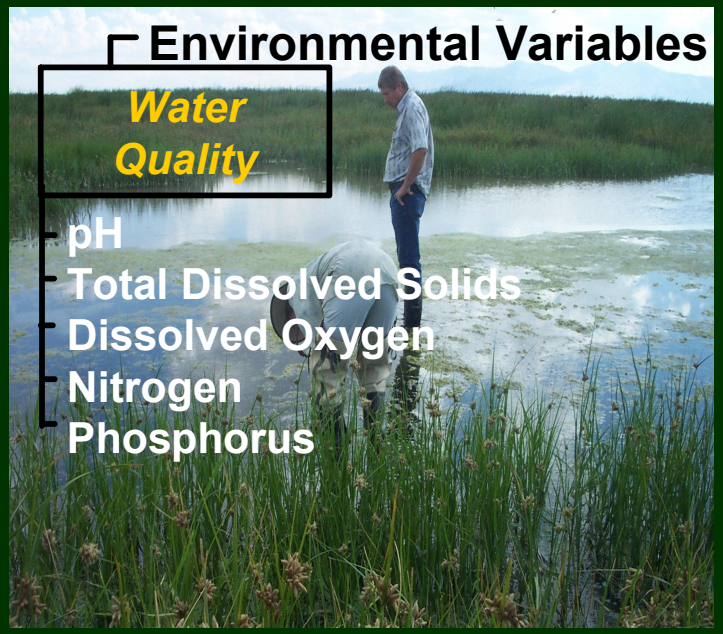
Farmington Bay Nutrient Pollution Studies



Beneficial Uses of FB

Important feeding and nesting grounds for migratory birds

Factor Analysis



Macroinvertebrates

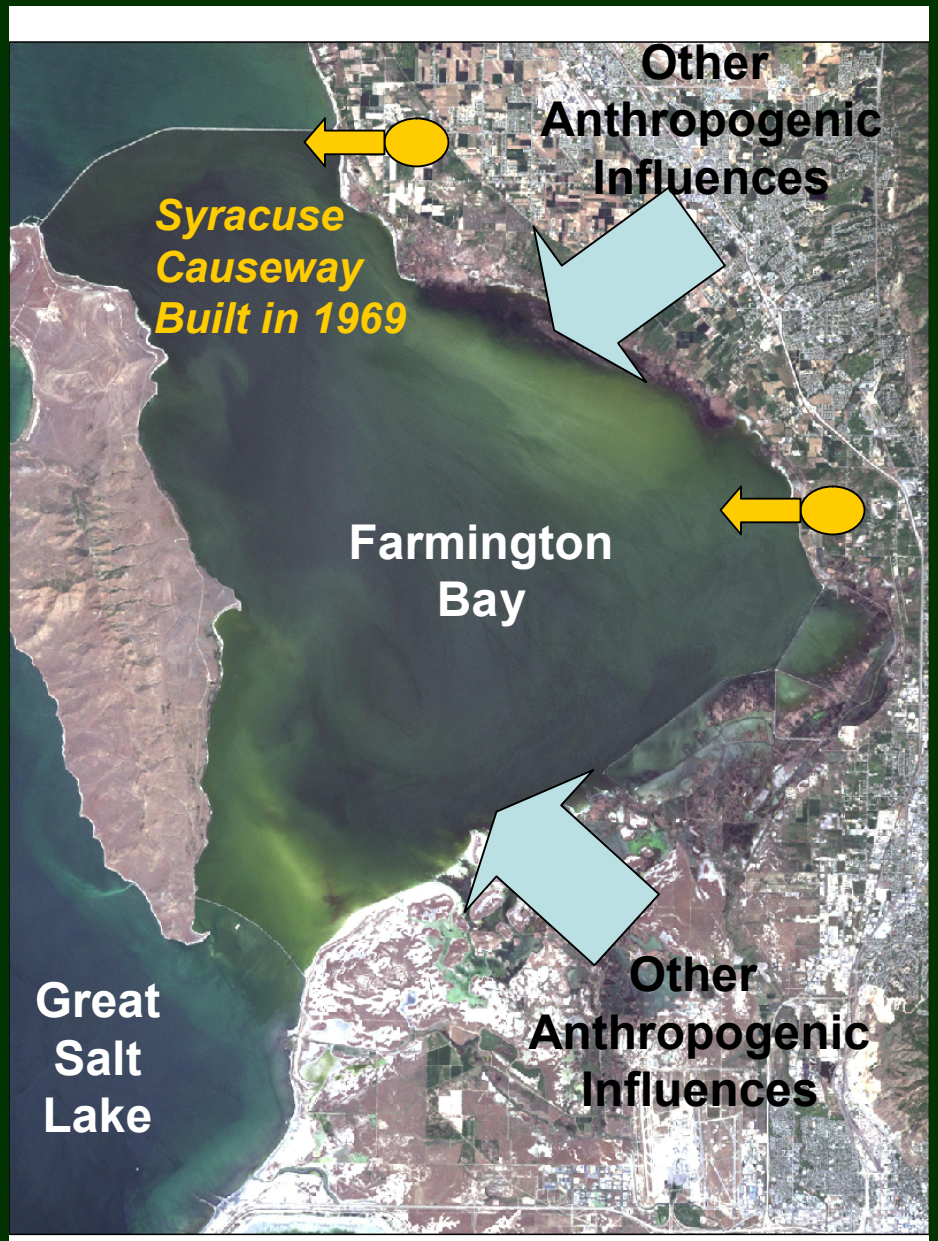
Vegetation

Water Quality Factor

Macroinvertebrate Factor

Vegetation Factor

Farmington Bay Stressors

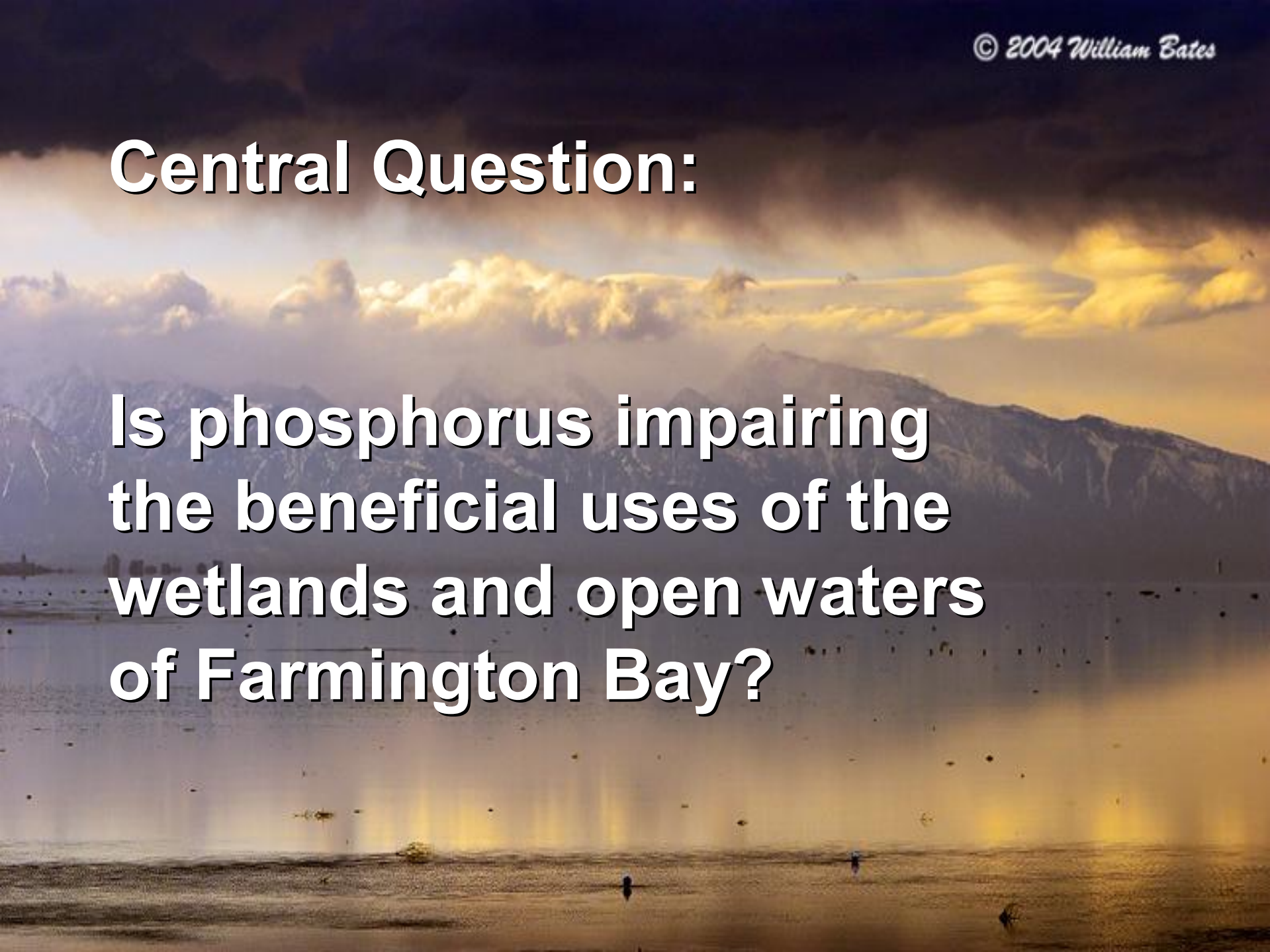


North Davis WWTP Discharge

Nutrients concentrate in FB - EUTROPHICATION

Central Davis WWTP Discharge

Reduced mixing between the Great Salt Lake and Farmington Bay



Central Question:

Is phosphorus impairing the beneficial uses of the wetlands and open waters of Farmington Bay?

Next Steps

- Continue studies on habitat use, feeding and nesting of birds, particularly juvenile survival.
- Plan studies on potential bio-accumulative effects of key pollutants (*e.g., Se, Hg*).

Budget for GSL Studies

Expenses		Revenues
Farmington Bay	$439,000	Nature Conservancy
Science Panel	$40,000	JVWCD
Se Model	$20,000	EPA
Mapping	$85,000	Central Davis SD
Lab	$210,000	North Davis SD
Contracts	$1,415,000	Forestry, Fore & State Lands
Miscellaneous	$53,000	Kennecott Utah Copper
		DWQ
Total	$2,262,000	

The History of Managing the Great Salt Lake

- Since statehood Utah believed it owned the GSL

- 1959: BLM challenged the State's claim to the land above 4201.8'.

- 1963: GSL Authority created to: coordinate multiple lake use; develop recreational aspects; protect property; and perform studies.

- 1966: Utah Supreme Court declares the GSL Authority unconstitutional. The legislature reconstitutes it in 1967 primarily for development of property.

- 1967: DNR created. GSL Authority abolished. Division of GSL established in 1975 to oversee recreation; flood control; wildlife; industry; and conservation. A CMP was developed in 1975.

The History of Managing the Great Salt Lake

- 1979: Division of GSL eliminated and duties are transferred to DNR and later to FF&SL.

- 1987: General Management Plan established.

- 1988: GSL Advisory Council created to advise FF&SL.

- 1997: GSL Tech Team prepares the GSL CMP. It is updated in 2000. Purpose expanded to include environmental protection.


What Lies Ahead?

The Bigger Picture

- Institute a Great Salt Lake Watershed Council as a precursor to establishing a Great Salt Lake Commission
- Investigate long-term funding mechanisms for research and protection of the Great Salt Lake
- Invite state, regional and national interest in the Great Salt Lake

- Mono Lake: $1.6 M annual operating budget

- San Francisco Bay Estuary Institute: $3 M annual budget for water quality monitoring

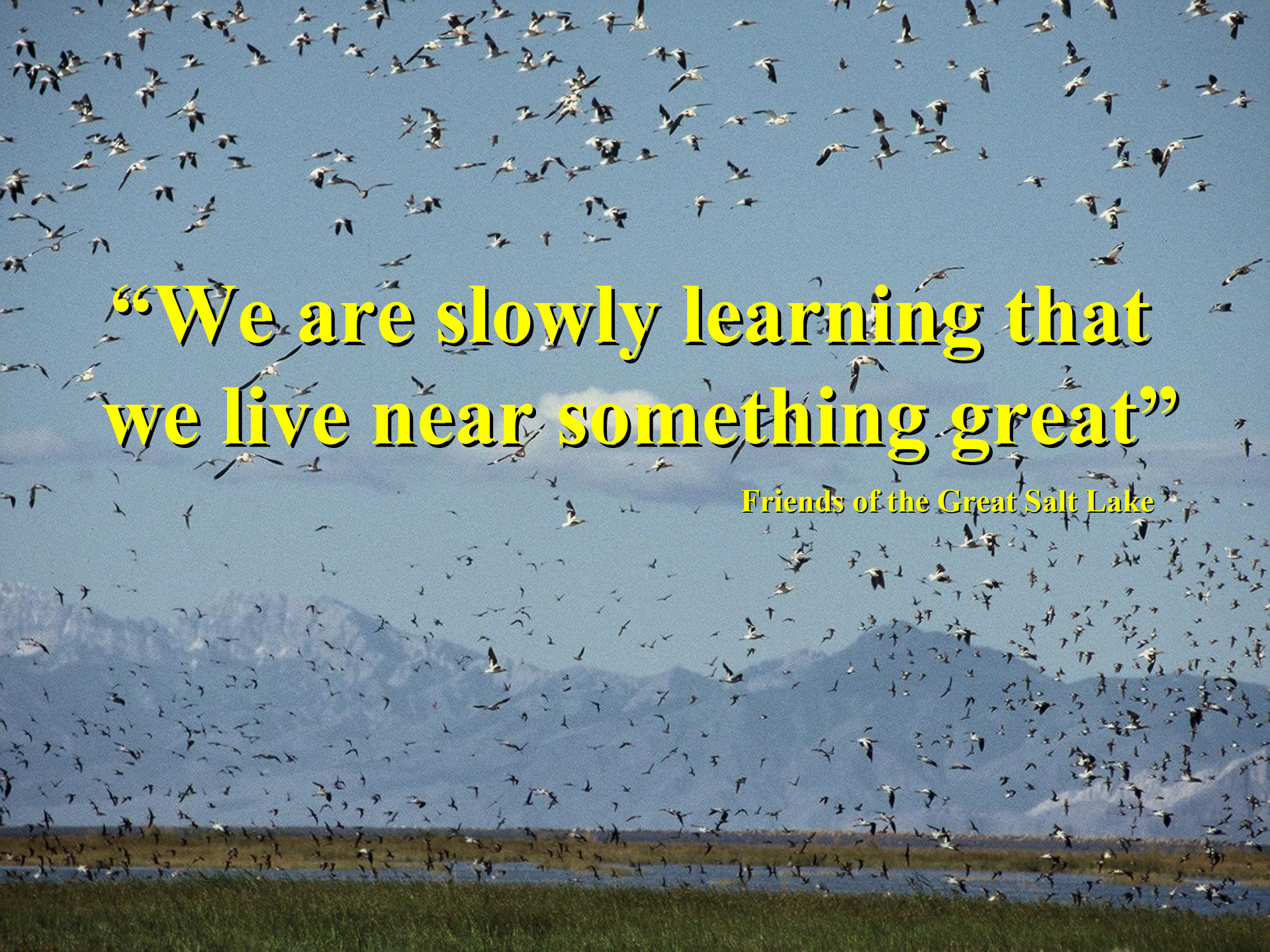
- Comprehensive Everglades Restoration Plan: $10.5 B (multi-year)

- Chesapeake Bay Program: $15 B over 6 years

- Great Lakes Commission: $20.5 M annual budget (U.S. & Canada)

- Puget Sound Partnership: $245.3 M annual budget

- Salton Sea: $400 M to $600 M annual sale of municipal bonds


“We are slowly learning that we live near something great”
Friends of the Great Salt Lake


Questions?
Great Salt Lake, Utah
© 20006, Paul Higgins